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Solar power investment in North Africa: Reducing perceived risks

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ABSTRACT

Climate protection targets for mid-century imply a need to scale up European renewable power production to a level that may exceed the available land area within Europe's borders. One attractive solution, from a cost and feasibility perspective, is the development of large-scale concentrating solar power plants in North Africa and the Middle East. However, these developments are seen by many people as risky, in terms of both European energy security, and in terms of the risks faced by project developers. In this paper, we focus on the latter of theses issues. First, we examine the risks that project developers are most concerned about, and identify these as being associated not with terrorism and rogue state behavior, but rather with corruption and inefficient and unpredictable bureaucracies. Second, we identify a range of policy approaches that can reduce these risks, either by mitigating their consequences, or by seeking to eliminate their underlying causes. Third, we investigate the financial benefits of taking such steps to reduce or eliminate investment risks. We find the potential savings to European electricity consumers to exceed €200 billion.

Contents

1. Introduction

The Intergovernmental Panel on Climate Change (IPCC) has estimated, in its fourth assessment report, that preventing potentially catastrophic levels of climate change will require stabilizing atmospheric CO_2 concentrations at or below 450 parts per million [32]. Achieving that would in turn require emissions cuts by 2050 of 50% globally and 80% in industrialized countries, with emissions cuts reaching 100% globally soon thereafter [35]. Unless demand for energy were to fall dramatically over this time period, a critical challenge in highly populated regions may simply be to find enough land to locate the renewable energy infrastructure needed to achieve these decarbonization targets. A recent analysis for Britain and Europe, for example, concluded that there is simply not enough space to produce the needed renewable energy domestically [24]. The analysis suggested three potential solutions to this problem: relying on carbon capture and storage (CCS) coupled to conventional fossil fuel power generation; scaling up the use of nuclear power to levels much greater than they are today; and, importing renewable energy from relatively unpopulated areas, most notably deserts. Given the existence of important safety concerns for each of the first two options, the third is at least deserving of serious analysis, in order to identify the potential policy pathways that could make it happen.

At present, the technology that appears most promising for generating power in the desert is concentrating solar power (CSP). CSP uses mirrors to concentrate sunlight on a thermal collector, which then drives a power generation process using either a steam turbine or a Sterling engine. Project developers have demonstrated the capacity to utilize thermal storage, in order to be able to

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dispatch power over periods of several hours when the sun is not shining. While CSP was first demonstrated at a commercial scale over twenty years ago, with a set of installations in California, United States of America (USA), its growth lagged far behind those of wind and solar photovoltaic (PV) during the 1990s and into the current decade. Led by a feed-in tariff for CSP in Spain and ambitious support in California, there has been a resurgence of interest in CSP. Over the last three years the global CSP generating capacity has more than doubled, to nearly 1 GW in 2010. Currently more than a dozen countries have CSP projects in development or under construction, with a planned capacity exceeding 15 GW [18].

While the southwest USA has a large amount of space suitable for CSP development, Europe is relatively lacking in undeveloped arid land. One obvious solution to Europe's needs, and that of its neighbors in the south, is to develop CSP in the Sahara Desert, for local power consumption in the Middle East and North Africa region (MENA) and to fuel electricity exports to Europe, via high voltage direct current (HVDC) cables [5]. A number of recent assessments have explored this possibility, and found it to be technically feasible and economically attractive [8,13,14,20,37].

Growing out of these technical analyses have been several political level proposals to pursue such a strategy. In 2008, the French government spearheaded the creation of the Union for the Mediterranean, and as a starting initiative for regional cooperation launched the Mediterranean Solar Plan (MSP). The MSP has a target of installing 20 GW of new solar and wind capacity, as well as improvements in energy efficiency, in the Mediterranean region by 2020. The MSP secretariat has also issued a call for proposals for new projects, and promises assistance in identifying potential sources of financing, including cooperation with multilateral finance and development agencies such as the World Bank. In 2009, a consortium of energy, technology, and financial services firms—most of them from Germany—came together to form the Desertec Industrial Initiative (DII), which announced plans to stimulate €440 billion in investment in CSP in the Sahara Desert [4].

From a central planner perspective, investment in CSP in the MENA region looks good. This is primarily because the costs for CSP are not very high, while at the same time the current installed capacity is very low. As an empirically grounded rule of thumb, the costs for a particular energy technology fall about 10–15% each time the total installed capacity doubles [25,40]; the result are what are known as "learning curves" for different technologies [2,36]. While there are clear limits to applying learning curves to estimate future changes in technology prices [31], they do offer a rough indication of how capacity increases will affect costs. Based on technology specific estimates of [30], Fig. 1 illustrates the potential for such cost reductions for different classes of technologies, associated with projected capacity increases. Thus, pushing wind capacity to match that of current nuclear capacity would make the least expensive wind competitive with the least expensive fossil fuels. For CSP, it suggests that pushing capacity up to about half of current wind capacity would result in costs falling to the same range, i.e., competitive with fossil fuels.

This birds-eye perspective on different technologies, however, ignores many of the issues driving investment by actual economic actors. While CSP may be attractive to policy-makers, to investors it may look less than ideal for a number of reasons. This is particularly the case in the context of North Africa and the MENA region more generally. The high volumes of investment envisioned by initiatives such as the MSP and DII would require participation of private capital. While the proposed DII investment volume is ambitious, the fact remains that European private investors have been cautious about investing in renewable energy projects in North Africa because of their perceptions of risks connected both with technology, and with the region [21]. While Chinese and Middle Eastern FDI has flown into the region, North African countries receive only 15% of European Union (EU) foreign direct investment (FDI); France, the United Kingdom, and Spain are the most important European investors. In Libya, Algeria and Egypt, FDI flows primarily to the hydrocarbon sector, in Tunisia primarily to the energy and manufacturing sector, and in Morocco to tourism, real estate and industrial sectors [39]. If indeed the development of CSP in the Sahara is to be an important piece of the renewable energy puzzle for Europe and North Africa, then it is crucial to identify some of the most important barriers to investment, as a precursor to developing effective policies.

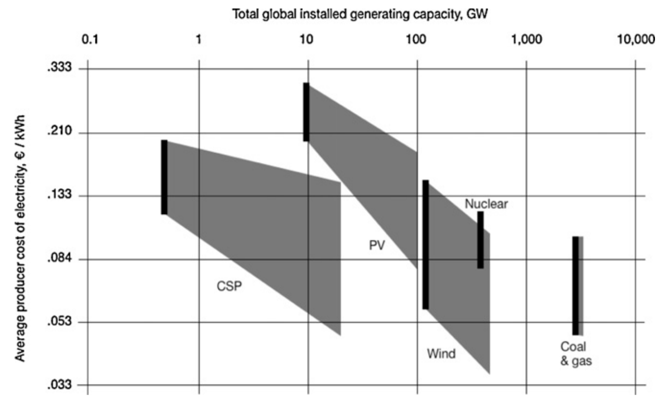

Fig. 1. Relative costs and capacities. Both scales are logarithmic, such that an increase in capacity by a particular distance on the horizontal scale corresponds to a linear decline on the vertical axis.
Sources for current capacities and costs: [13,33,46]. Source for capacity scenarios: [11]. Source for learning rate projections: [30].

In this paper, we examine the problem in terms of the risks that investors face, focusing on the North Africa region. First, we review the recent literature to identify which risks are perceived as being most important to foreign investors, and thus creating potential roadblocks to the expansion of renewable capacity in North Africa. These results are largely from outside of the renewable energy sector, but also include a recent survey of investors in CSP [22]. By risk perceptions we mean the subjective judgments that people make about the characteristics and severity of a risk, which are closely connected with how much risk people are willing to accept [34], and with their decisions whether or not to invest in a certain technology [10]. Second, we present a catalogue of policies and measures that could be used to address the risks perceived as most important. We draw these from the grey literature, focusing on efforts from non-governmental organizations such as Transparency International, and multilateral organizations such as the World Bank. Third, and most importantly, we present new results suggesting the economic benefits that would accrue from implementing such policies and measures successfully. To do so, we use the MARGE scenario generator described in Williges et al. [44], using it examining the sensitivity of total investment and subsidies required to scale up CSP capacity in the region to variation in the perceived risks associated with individual projects. While the first two pieces are specific for the North African region, the results of this third analysis could be generalized to other regions where CSP is an attractive technology. We conclude with policy recommendations, namely suggesting the benefits of the policies and measures we identify far outweigh the costs.

2. Risk and the investor perspective

What are firms investing in the power market looking for? It is axiomatic that they are hoping to earn profits, and that as particular forms of investment promise higher expected profits, the level of investment in them will increase. But it is also fairly clear

that they hope to minimize risk. Thus, even if a given investment promises expected profits, if the possibility of losing money is too large, investors will stay away. In economic theory, such behavior is known as risk aversion, and is a long-accepted feature of behavior [3,41]. Many financial instruments, most notably insurance but also other hedging contracts, allow investors to reduce their risk at some cost to expected profits. Often, however, the markets for such instruments fail due to information asymmetries and other barriers, and investors are left with significant amounts of risk [29].

The extent to which risk aversion influences behavior in energy markets remains open to debate. It is difficult to measure levels of risk aversion in firm behavior, because—in contrast to individuals participating in laboratory experiments [42]—it is very difficult to obtain reliable information about the expectations of firms as they enter into risky investments [17,28]. Most energy models (e.g., [27]) assume that firms are risk neutral, either because they can reduce any risks at minimal costs through financial markets, or simply because reliable estimates for how to calibrate the level of risk aversion are lacking. A number of qualitative studies, nevertheless, show risk aversion to play an important role. In a study that was part of the European-funded project “Assessment and optimisation of renewable support schemes in the European electricity market” (OPT-RES). Coenraads et al. [7] found that renewable project developers had a great deal of difficulty obtaining financing for projects that banks perceived to be in any way risky. Similarly, studies that have examined the effectiveness of the feed-in tariff system for renewable energy support have noted that it is quite successful, relative to other policy instruments, because it reduces the downside risk associated with project development, and in that way makes it easier to attract finance [9,26]. It is thus safe to conclude that risk aversion plays an important role in energy markets, even if it is difficult to determine how large that role is.

All large energy projects involve a measure of technical and market risk, but investment in North African countries could raise additional concerns, namely the issue of political risks. Khattab et al. [1] interviewed FDI stakeholders active in developing countries, and reported that political risks, including regulations and political stability, were identified more frequently as a cause of concern (76% of all respondents) than financial (63%), cultural (40%), and natural (16%) risks. A related study identified three types of risks as the most important for FDI actors: those connected with the effects of state monopoly, with the lack of a stable legal framework, and with bad corporate and public governance, including corruption and bureaucratic procedures [6]. While the geographic focus of both of these studies was not North Africa, they do provide important insight. The World Bank conducted a series of assessments to measure levels of risk in North Africa countries. Looking at issues of government accountability, ease of doing business, and challenges specific to FDI, the studies showed that North African countries did not fare particularly well, in most cases in the middle- to lower-third of global country rankings (World Bank, 2008a).

Komendantova et al. [22] extended this work by interviewing stakeholders in the business of renewable energy development in North Africa. The researchers conducted two rounds of interviews, identifying risks that caused concerns to investors in relation to renewable energy projects in North Africa. The first round were unstructured interviews, when 23 stakeholders from industry, government ministries, financial sector and social scientific community were asked to identify the major barriers and risks connected with investment into renewable energy capacities in North Africa for local use and further transition of electricity to Europe. The researchers choose these stakeholders from participants in conferences and workshops focusing on the MSP and DII. All respondents were stakeholders from Europe who were active in concentrated solar power projects in North Africa.

More than half of all respondents identified the complexity of bureaucratic procedures and corruption as significant barriers. Other risks identified as significant barriers were the instability of national regulations, the absence of guarantees from national governments and the international community on invested capital and revenues from projects, a low level of political stability, and the lack of support from local governments including commitment and cooperation. The latter was due mostly as a result of a low level of awareness about the advantages of renewable energy sources.

During the second round of semi-structured telephone interviews, the researchers asked 18 experts from industry, ministries, financial sector, and the social scientific community to rank the risks according to their perception of seriousness of concern and likelihood to happen. The list of risks contained nine classes: technical, construction, operating, revenue, financial, *force majeure*, regulatory, environmental, and political. The researchers defined *force majeure* risk as something outside the control of parties, including Acts of God, such as tornadoes and hurricanes, or acts of humans, such as a strike, terrorist attack, or other such disruptive event [12]. The seriousness of concern was evaluated according to the following scores: 3 as high importance, 2 as medium importance, 1 as low importance. The likelihood to happen was evaluated according to the following percentages: very likely (>90% chance of occurring), medium likely (33–89%), and unlikely (<33%).

Fig. 2 shows that of the nine classes of risk, only three were rated as being of a high level of concern by at least one of the experts. These are regulatory risks (which includes complexity and corruption of bureaucratic procedures and instability of national regulations), political risks (including low level of political stability in a country and the lack of support from local governments) and *force majeure* risks (which include natural and human-made disasters, including terrorism). All other six classes such as technical, construction, operation, financial, revenue and environmental were evaluated as low or medium important. Both evaluations of seriousness of concern and likelihood to happen showed that the risk of inappropriate bureaucratic procedures and corruption was evaluated as very serious for North African region and most likely to happen under present conditions.

Many respondents noted that investment often does not happen at all because of complex and lengthy bureaucratic procedures and unpredictable investment volumes due to corruption. The evaluations of the political situation in the region were homogenous: the risk of unstable political situation is perceived with medium level of concern by investors and they think that its likelihood to happen is medium. The evaluations of *force majeure* risk—mainly terrorism—are less clear. The evaluations of seriousness of concern about it are strongly polarized—in terms of seeing it as serious or not—but it seems that even though this type of risk is perceived

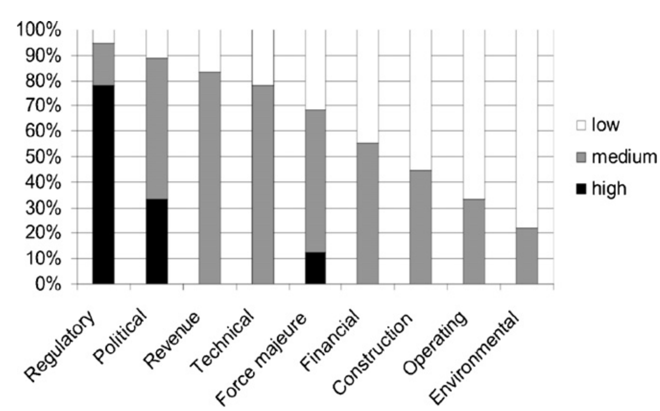

Fig. 2. Risks perceived as being most serious by investors ($n = 18$). Source: [22].

with high level of concern by small part of investors they still think that its probability to happen is low [22].

3. Policies to address risk

Within developed countries, it is clear that different policies to support renewable energy development have very different impacts on investor risk. Mendonça [26] documents that feed-in tariffs have been particularly successful at stimulating investment in Europe, compared to quota systems, precisely because they lower risk: the tariffs guarantee project developers a fixed price for the power they sell, rather than leaving open the uncertainty that the project developer will be unable to sell the power on the market at a price sufficient to cover the amortized fixed costs. The only remaining risks that investors face are potential fluctuations in the interest they must pay on loans, and fluctuating power output due to weather. By contrast, project developers under a quota system face the risk of not being the lowest cost provider of renewable power, in the case of the quota being exceeded, in which case they could lose money. This has limited the access to capital that projects developers have had in countries with quota systems, and either slowed the pace of development or increased their costs, due to higher financing costs.

Clearly, if it is desirable to stimulate CSP development in North Africa, then it would be necessary to put in place some sort of renewable support scheme, at least until the cost of CSP falls to be competitive with fossil fuels. A support scheme that reduces investor risk, such as the feed-in tariff or the set of tax credits similar to those used in the United States, would appear to be preferable from a risk standpoint.

The renewable support scheme, however, would not address the special risks present in North Africa, compared to investment in Europe, which could result in delays in construction time, or future interruptions in supply due not just to weather, but also to human actions. While there is no clear set of policies that have been demonstrated to deal with these risks for energy projects at a scale envisioned for CSP for North Africa, there are existing policies and programs that could potentially be adapted to the energy sector and scaled up accordingly.

One set of policies would directly address risk, or at least the cost of risk, through financing schemes. In addition to insurance offered by private companies, public agencies have a history of offering insurance to project developers in developing countries to cover political risks. The largest such program is the Multilateral Investment Guarantee Agency (MIGA) from the World Bank group. MIGA covers such risks as political violence, including war and civil disturbance, government actions resulting in expropriation and repudiation of contracts, and any other government actions resulting in losses for business. In case of terrorism, war or civil disturbance, the insurance pays the book value of the project assets, their replacement cost, and the cost of repairing damaged assets. In case of temporary business interruption caused by host government actions, MIGA pays the unavoidable expenses and lost business income or missed payments. The insurance can reduce a project's risk rating or help to improve its credit rating, both of which can have the effect of reducing project financing costs.

Similarly, international finance and development agencies have a history of offering low-rate loans and guarantees on loan payments for infrastructure projects in developing countries. They include low rates loans with interest rates much below of those from commercial banks and often for a longer period and guarantees on loans, which cover a part of whole interest rates for loans received on the private market. These financing instruments can help to reduce expectations of Internal Rate of Return from the side of private investors thus reducing the overall costs of the project.

Finally, private–public partnerships are often used in infrastructure projects or any other projects, which are in responsibility of the state but involve private partners to improve the quality of management or to secure financing. They have several forms when private business finances, constructs, manages, operates and/or owns an asset. This financing scheme allows realization of the project even in a situation of severe constraints of public budgets as the government has possibility to pay for an asset after its construction or to share financing burden with private partners. For private partners it gives additional security against the risks by providing access to low interest rates loans from national governments and to state assets, as well in several cases government covers revenue risks by providing guarantees for project output.

A second set of policies aims to address the underlying causes of risk in developing countries, as compared to industrialized countries, through regulatory reform and improvements in government accountability and effectiveness. The European Union and international organizations are implementing a set of programs in North Africa, aiming to increase the level of political and economic stability in the region as well as to improve regulatory and legal architecture. These programs, if they work, might decrease risks perceptions of investors connected with the region. The European Commission established in the frame of the European Neighborhood Policy the Mediterranean Energy *measures d'accompagnement* (MEDA) program, the budget of which is still too small (€5 million) to make any significant change in the region. The Euro-Mediterranean Partnership, also known as the Barcelona Process, aims to promote long-term political stability in the region through economic development, elimination of trade barriers and liberalization. The results are controversial. It has increased dialogue at elite political level, yet its implementation has corresponded with a decrease of living conditions of North Africans [38]. It did not lead to the magnitude of increase of European foreign direct investment (FDI) to the labor-intensive sectors that its proponents had promised, other than in the hydrocarbon energy business.

Other international programs are focused explicitly on administrative barriers in North Africa, as the investment climate in the region is heavily influenced by ineffective bureaucracies [45]. These not only increase risks and costs to business for new investment, but also decrease the quality and efficiency of already existing investments. The Organization for Economic Cooperation and Development (OECD) and the United Nations Development Programme (UNDP) launched a program for the period 2008–2010 in support of good governance for development in Arab countries. The focus of a second UNDP program is on anti-corruption and the rule of law (UNDP-POGAR) for the period 2008–2010, and aims to help countries reform their judicial systems to allow for more efficient settlement of economic disputes and enforcement of judgments.

Closely related to these are programs aimed specifically at reducing corruption in contract awarding. The Extractive Industries Transparency Initiative (EITI) is the best example of a program to achieve this. It is a voluntary program involving country governments and the resource extraction companies doing business there, whereby all financial transactions between the two are made public and audited. Only two countries—Liberia and Azerbaijan—have been certified as in complete compliance with EITI reporting guidelines, while an additional 33 countries are currently in the application or validation stages. No North African country is currently involved in the program. As it is structured, the EITI would not cover the business of solar energy development, but it is not difficult to imagine a similar program that would do so.

For now, the practice of offering insurance, low rate loans, loan guarantees, and structuring projects, as public private partnerships have proven effective. By contrast, the results of those programs

aimed at political and regulatory reform remain unclear. In the long run, efforts to address the underlying risk factors will be necessary, and to the extent they are successful could reduce or eliminate the need for special financing programs addressing political risks in these countries. In the short run, both would be important policy avenues to pursue.

4. The financial benefits of risk reduction

Policies to reduce risk do not come without cost, both financial and political. While it is beyond the scope of this paper to estimate these costs, what we do attempt in this section is to identify the benefits that such efforts would bring. We begin by reviewing past studies that serve as a starting point for estimation, and then move on to develop a set of scenarios that suggest actual savings.

4.1. Review of existing cost studies

To examine the financial benefits of reducing risks, it is useful to start by reviewing past economic studies on the scaling up of CSP investment in the Sahara Desert. The best known of these are a series of reports prepared by the Institute of Technical Thermodynamics at the German Aerospace Center (DLR). These suggested that scaling up CSP in the MENA region would be feasible and not prohibitively expensive [13], that linking this power to Europe via HVDC lines would be practical [14], and that the development of CSP could provide substantial side benefits for the MENA region, such as desalinated water [15]. The DLR studies formed the basis of scenarios proposed by the DII. A second study was conducted at the University of Kassel in Germany, and suggested that a combination of renewable sources—including large amounts of both wind and CSP in the MENA region—could supply 100% of Europe's energy needs while maintaining the existing system reliability [8]. Assuming no changes in technology costs from the present, the study calculated the average cost of electricity using such a system at about 0.08 €/kWh, which is close to the existing average producer cost of electricity across Europe, and substantially less than the consumer price of electricity in all European countries. A third study, prepared by a research institute in Washington, DC, examined in detail the costs of building 20 GW of CSP capacity in the MENA region [37]. It assumed that project developers would benefit from the Clean Development Mechanism for that share of the power consumed locally, while competing against power generators covered by the European Emissions Trading System (ETS) for that share of the power exported to Europe. Taking this into account, Ummel and Wheeler [37] suggested that the total amount of additional subsidy required to build this 20 GW of capacity would be less than 20 billion US Dollars. Furthermore, the study suggested that by building these 20 GW of capacity, the costs of CSP would fall to be competitive with those of coal, again assuming that coal-fired power plant operators would have to purchase emissions allowances via the EU carbon market.

Finally, a study conducted at the International Institute for Applied Systems Analysis (IIASA) and the Potsdam Institute for Climate Impact Research (PIK) addressed the same issue of required subsidies, but explored the sensitivities of these subsidies to a number of factors that remain highly uncertain [43]. In their baseline scenario, they assumed that the price of coal-fired power would remain constant at its current price of 0.045 €/kWh, that the carbon price would again drop to zero because of continued difficulties with the ETS, that technology costs would fall by 15% each time installed capacity doubled, and that the capacity of CSP in the MENA region for export to Europe would rise by 25% annually. Under this scenario, CSP would reach cost parity with coal by 2035, after 355 GW of capacity had been installed in the MENA region and an equal amount elsewhere (including California). The total discounted investment costs for the MENA share of this would be €210 billion, while the share of those investment costs for which subsidies would be required would be €65 billion. Other scenarios changed assumptions about the learning rate, the cost of coal, and the rate of return demanding by project financers. For each scenario, they varied one assumption at a time, while leaving the others as they were in the baseline scenario. The range of subsidies required was from €19 billion (when the return on investment for CSP plants was lowered to 5%), to almost €400 billion (when the learning rate was assumed to be not 15%, but 10%). What is interesting about these findings is that the factor that reduced investment costs the most was a reduction in the return on investment required. Ordinarily, this would happen as a result of a change in perceived risk levels associated with a project, as investors require lower returns for projects they see as risk-free, and demand large risk premiums for projects perceived as risky.

4.2. Alternative risk scenarios

To examine the benefits of risk reduction in greater detail than these past studies have done, we construct a number of scenarios associated with the scaling up of CSP, and examine the effects of changing the perceived risks to investors. We use the model first described by Williges et al. [43]—the Mediterranean Area Renewable Generation Estimator (MARGE)—and use it to concentrate on the issue of risk. MARGE consists of two linked sub-models. The first sub-model takes input parameters from the users concerning the scaling up of global CSP development over the coming decades, combining these with empirically-estimated learning curves, to model changes in technology costs over time for the components of a CSP plant and associated HVDC transmission infrastructure. The second sub-model calculates the component costs associated with geographically specified CSP plants in North Africa, and the associated HVDC transmission infrastructure to European grid feed-in locations, at points in time along that scenario.

MARGE allows for the examination of alternative assumptions about perceived risk by changing the internal rate of return (IRR) that new CSP projects must deliver, which changes the annual cost associated with capital infrastructure. This is commonly the way in which risk is reflected in project financing, which in practice is often very complicated. Grimsey and Lewis [16], for example, describe a financing structure for a public private partnership to construct a large infrastructure project in Europe. In this case, 80% of the finance was obtained with a bond providing a fixed 5.822% interest rate, and additional 15% was obtained through subordinated debt paying the same rate, and 5% was obtained through private equity with a projected IRR of 12.5%; the resulting cost of capital averaged 6.2%. The cost of capital tends to be higher in developing countries; for example, Lund et al. [23] reported on a new coal-fired power plant in Thailand guaranteeing an average 15% IRR to its debt and equity investors. The evidence from the power industry suggests that project developers for conventional thermal power stations need to guarantee an IRR in the range of 6–10%, while developers of large renewable power plants—such as CSP plants in Spain—face costs of capital exceeding 15%, due to banks' apparent view that the technology may not be commercially viable. It is certainly foreseeable that private developers of CSP projects in the MENA region could face rates of as much as 20%. Arguably if there were no risk at all associated with a project development—such as could be achieved through a government loan guarantee—then the IRR could sink to the risk-free interest rate, currently about 1%, but more commonly closer to 5%.

We examined the effects of varying the IRR for new CSP plants in North Africa from between 0% and 20%. At 0%, the average costs of electricity would be determined by the depreciation of the capital

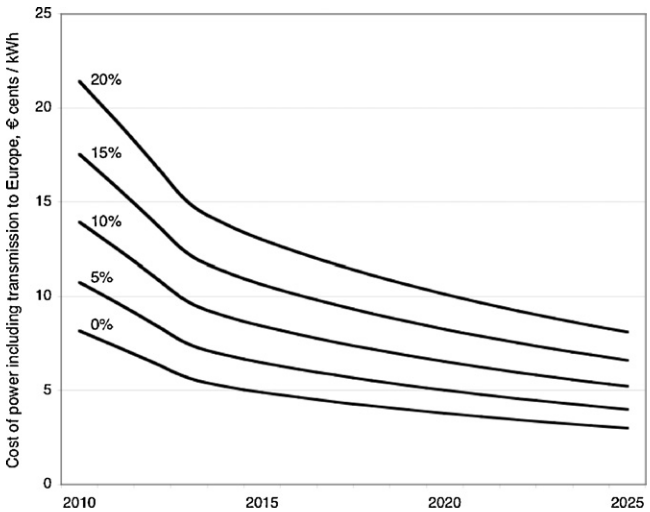

Fig. 3. Levelized electricity cost (LEC) curves for CSP assuming different internal rates of return. Each curve represents a different rate that project developers must pay their investors.

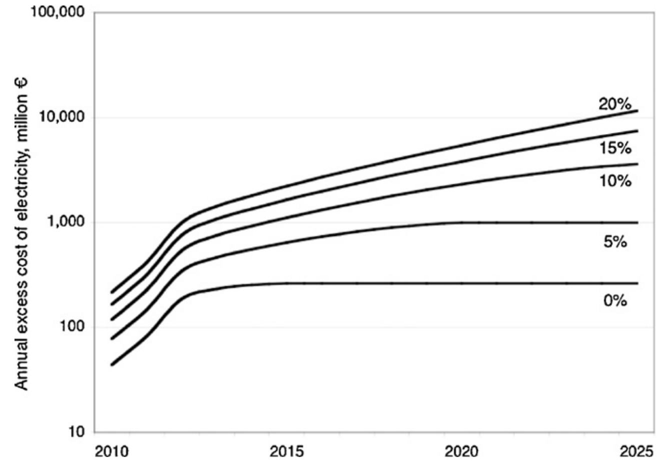

Fig. 4. Required subsidies to support CSP project development assuming different internal rates of return.

investment, plus the operation and maintenance (O&M) costs for the plants and transmission lines. At all positive interest rates, the project developer would additionally have to pay interest on the capital investment until it is fully depreciated. To parameterize the model, we assume that currently planned CSP projects will be developed, and then beginning in 2015 there will be a 25% annual increase in total installed capacity through 2025, roughly equivalent to the growth rate wind power has experienced over the last decade [19]. We assume that CSP plants will have a thermal storage capacity of 16 h and guarantee base-load, which would allow them to replace coal-fired plants. We assume a learning rate of 15%, meaning that costs for new capacity fall by 15% each time global installed capacity doubles. We assume equal amounts of investment in North Africa and the rest of the world, and calculate the investment costs and levelized electricity costs (LECs) of CSP plants distributed evenly across optimal sites in Morocco, Tunisia, Algeria, Libya, and Egypt, with the associated HVDC transmission to Europe. For the transmission corridors, we rely on scenarios developed by the DLR [14].

Fig. 3 shows the results of varying the IRR on the LECs. Each curve represents a projected cost evolution as a result of learning, with the only difference being the rates of return that project developers must pay their investors. The results show that the LECs vary by a factor of three, depending on the IRR. More importantly, changing the IRR has a large impact on the time at which the cost of CSP falls to a point where it is competitive with coal. If the rate of return to investors were close to 0%—potentially feasible for a purely public investment—then CSP would become competitive with privately developed coal power in about 5 years, about the time when the currently planned projects will have been completed. At a 5% rate—not unreasonable for a public private partnership with very low perceived risk—CSP would become competitive by 2020. At higher IRRs, the year in which CSP would become cost competitive with coal would be pushed back to beyond 2025.

The second piece of analysis is to consider the benefits, in terms of the amount of state or public subsidy required to stimulate investment, of reducing projects IRRs. There are many policy instruments that have the effect of a subsidy. Tax credits as used in the United States, for example, create a direct subsidy from the state. By contrast, both renewable quotas and feed-in tariffs create a subsidy paid by electricity consumers, as both require the grid operator to purchase renewable power at an LEC higher than the market rate for conventional thermal power. Putting a price on carbon, such as through the ETS, also has the same effect. The ETS raises the wholesale cost of electricity that all power plant operators receive, with the exact difference determined by the carbon intensity of the highest-cost plant in the merit order actually supplying power. Operators of CO_2 emitting plants will use these additional revenues to acquire the necessary carbon permits, with the costs of those permits funneled back to the state, while operators of plants not emitting CO_2 will keep these revenues. Thus the subsidy amount is insensitive to the carbon price, but only determined be the difference in LECs between the CSP plant and the power plant it replaces. We assume this to be coal, with a constant LEC over time of 0.05 €/kWh.

Fig. 4 shows the results. Each curve represents a subsidy path associated with a different IRR, calculated until 2025. It is important to note that the vertical axis is on a logarithmic scale, required since the annual subsidies required by 2025 differ by over an order of magnitude, from €263 million for the 0% scenario to €11.6 billion for the 20% scenario. It is also important to note that the subsidies flatten for the 0% case in 2015, and for the 5% case in 2020. This reflects the fact that new plants built after these years do not require any subsidies, and hence the subsidies only need to be paid for the remaining lifetimes of plants already in operation. Once these plants are retired at some point in the future—or in the case of a feed-in tariff the contractual obligation to purchase power from them at a particular LEC is no longer in force—the subsidies would begin to fall, eventually to zero. The difference in the total subsidy required is also impressive. The net present value (discounted as 5%) of the subsidies required until 2025 are €3 billion for the 0% IRR, €10 billion for the 5% IRR, €34 for the 10% IRR, €94 billion for the 15% IRR, and €238 billion for the 20% IRR. Hence taking measures to reduce the cost of capital for CSP projects—through some set of policies addressing risk—could save European consumers hundreds of billions of Euros over the next fifteen years in the context of an ambitious CSP subsidy scheme.

5. Discussion

Risk is an important and under-researched issue in the economics of renewable energy development. In this paper, we have examined the particular risk issues associated with project finance in North African countries, and our results suggest some important lessons.

First, the literature review on the risks that investors in North African countries perceive to be greatest shows that the problem is tractable. If the greatest concern were terrorism, for example, it would be difficult to identify policies that could reduce that risk

with high reliability; two wars fought by the United States and European countries in the last five years, for example, have not had any demonstrable result. Fortunately, terrorism is not the major concern. Rather it is the more mundane problems resulting from political corruption and inefficient bureaucracies. These lead to cost overruns and delays in the planning and construction phases of project development, threatening the profitability of the venture. Of less concern are events that could lead to interruption of operations once a project has been become operational, such as from political interference.

Second, there are a variety of policy instruments that can address the risks caused through poor governance, which could be applied to solar project developments. The most effective in the short term are those that manage existing risks, through the supply of insurance by international organizations, and which align the incentives between host governments and project developers through public private partnerships. Indeed, the latter is already a feature of large-scale energy development in North Africa, and would likely to continue. On a longer-term basis, it will be important for North African countries to take steps to improve their own government accountability. Here, there are a number of programs that could be applied. All of these measures are seen as essential for the sustainable development of countries in the region. The lessons from this analysis suggest that they could also be essential for helping Europe to solve its climate protection problem.

The third point is that the potential benefits of addressing the perceived risks of doing business in North Africa are enormous. By lowering the cost of borrowing capital, it decreases the electricity costs by several cents per kWh. Essentially, the additional costs of developing CSP in the region—compared to burning coal in Europe—are very close to the cost of the perceived risk. Comparing, for example, the cases of setting the IRR at 10% with setting it at 20%, the subsidies required between now and 2025 would fall by over €200 billion.

Addressing these risk issues will take concerted action by policy makers from both North Africa and Europe. They are not problems that private markets can solve on their own. Hence, any efforts to support project development through renewable support schemes aimed at North Africa will require the additional attention to these risk issues. To meet the ambitious targets of initiatives such as the MSP or the DII, dialogue between business and government on policy options should ideally commence as soon as possible.

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